

Microworld of an Open University: A Strategic Management Learning Laboratory

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ABSTRACT

This paper describes the work and experience gained by a team using a systems thinking approach to developing a microworld to support the strategic planning of Athabasca University (AU), a fast growing open university in western Canada. The opportunity for this experience arose from an invitation by the university President to teach an introductory course in Systems Thinking to a group of 30 senior management representing the faculty, administration, and the governing council. This work is intended to aid in understanding the dynamic forces which have allowed AU to double the number of course registrations in the past five years while lowering the cost to government of providing access to AU from \$1,179 to \$635 per course registration (in constant dollars) since 1985. This work reports the experience of AU in building a Microworlds® system in order to accelerate organizational learning. The system is based on the system dynamics methodology and was developed using STELLA®. The system has been used to test different scenarios of strategic options which are almost impossible to evaluate otherwise. The system was validated against actual data and was used as management flight simulator to simulate the system till year 2000. Repeated runs of the simulations have proved that quick fixes to one part of the system do not necessarily help its overall performance. It has been found that the process of constructing a simulation model is as valuable for problem solving as the final model itself.

BACKGROUND

The External Environment

Continuous budget cuts, increased competition, and explosive technological, political and environmental changes constitute major threats to the traditional management practices of open universities. In facing these problems, AU has recognized the importance of organizational learning to achieve sustained improvement in performance over a long period of time. As Analog Devices' CEO Ray Stata wrote in the *Sloan Management Review* "I would argue that the rate at which individuals and organizations learn may be the only sustainable competitive advantage" (Stata, 1989). Considerable recent research has addressed the issues of, How do organizations learn? What values, structures tools and processes are supportive of a learning organizations? How do we get there from here? (Senge and Sterman, 1990).

Distance Education at AU

AU is the largest open university in Canada. AU's primary mode of delivery is "home study" comprising 86 percent of registrations. The rate of successful course completion in this mode has increased from 46 to 58 percent since 1987/88. AU student population has grown to about 12,000 since its establishment in 1970, and these students registered in about 20,000 course registrations. Course registration has doubled in the last five years, and AU is planning to double course registration again by the year 2000. AU has 6 undergraduate degree programs, 8 certificate programs, and is planning to offer graduate programs leading to an MBA and MA in Distance Education in the near future.

Course packages are developed by AU academic staff members, produced by AU graphical designing and printing facility, and mailed to home-study students. In many cases, lack of internal faculty resources for course development forces AU to hire external Subject Matter Experts (SME) to develop courses. Students can seek tutorial help from assigned tutors at certain hours by phone. AU has 76 full-time academic staff who spend their working time in course development (new courses and revision of old ones), course delivery (tutoring and tutors coordination), research, university and community service. Almost half of AU academic staff time is spent in course development. A course package may include some of the following: a textbook, an AU study guide, an AU student manual, an assignment booklet, exams, video/audio materials, readings, and AU forms. Three main types of course packages (in increasing order of time required for course development and production) are: 1) a ready-made course package, 2) a wrap-around course package, and 3) a ground-up course package. Course development and production at AU is mainly focused on wrap-around and ground-up courses and there are five major steps in the process. The steps are as follows: 1) course approval, 2) course writing, 3) course editing, 4) graphical design, and 5) course printing. The course development and production model consists of 6 subsystems, each representing a queue. These sub-systems are: the proposal queue, the author queue, the editing queue, the design queue, the printing queue, and the open courses list.

Increasing pressure of demand for university services requires that, within a limited expenditure base, future growth must come from continued research and innovation in distance education methodology, as well as strategic investments in technology to increase staff productivity thereby meeting the demand for a flexible university education. AU has become a model for excellence in distance education. Course delivery at the university is primarily accomplished through a home-study distance education delivery system. The faculty coordinate the management and delivery of all course offerings with the assistance of telephone tutors who are scattered across the province but primarily are located in the large regional municipalities.

THE LEARNING LABORATORY

According to Steve Peterson (1990), the learning laboratory refers to a personal computer based arena in which managers are free to learn using their own style, at their own pace, and in a sequence that they determine. One or more simulation models provide the "engine" for learning within the environment. A learning environment thus is a vehicle for active, learner-directed learning. An effective learning environment will facilitate learners as they reconstruct the substance of the environment. An effective learning environment has two fundamental characteristics. First, it provides tools that facilitate the development of five critical thinking skills. These skills are: Dynamic Thinking, Generic Thinking, Structural Thinking, Operational Thinking and Scientific Thinking. These five skills are discussed in detail by Richmond (1990). Second, an effective environment engages the user in the learning process. By providing a rich context, as well as a contextual "puzzle", the environment will tap the inherent motivation of the learner.

Microworlds®

A "learning organization" is characterized by its attention to enhancing thinking processes that lay behind decision making. Furthermore, learning is encouraged through experimentation and testing in *Microworlds®* (Senge, 1990). Although learning organizations have attributes along many dimensions, the interesting point is that (a) they have an exploratory attitude and (b) current solutions and processes are open to questioning (Argyris and Schön, 1978). One new approach for accelerated organizational learning involves building "learning laboratories", "microworlds", or "management flight simulators". These learning laboratories are microcosms of real business settings, where managers can play roles in a simulated organization. A simulated microworld compresses time and space, allowing managers to experience the long-term, system-wide consequences of decisions (Sterman 1988; Graham, Senge, Sterman, and Morecroft 1989). As Senge and Sterman (1990) indicated, "an effective learning laboratory is much more than just company simulation. It trains managers and teams in the full learning cycle, as originally conceived by John Dewey: Discover - Invent - Produce - Reflect. Specifically, it develops skills in articulating hypotheses and reflecting on the outcomes of actions to confirm or disconfirm hypotheses, tasks in which most people are rationally undisciplined (Hogarth 1987). The result is greater awareness of the assumptions underlying policies and strategies, better systems thinking skills, shared understanding of complex issues, and enhanced individual and group learning skills.

As Bakken, Gould, and Kim (1991) emphasized, a *Management Flight Simulator* is a learning tool that allows managers to compress time and space, experiment with various strategies, and learn from making rounds of simulated decisions. Embedded

in specially designed learning environments called learning labs, these simulations can be designed to provide organizational "practical fields" (Senge, 1990) where managers can experiment and learn in an environment that allows failure and reflection. Management flight simulation can be regarded as a framing tool for dynamic issues, often referred to as transitional objects (Papert, 1981). Moreover, thinking can be more structured and discussion more productive, since discussions can be focused around a computer model that help de-personalize assumptions and make them less threatening. For decision makers, simulation and gaming have been successful in making scenarios interactive, flexible, vivid, logically consistent, and explicitly related to underlying assumptions.

Systems Thinking

The research draws on the system dynamics methodology developed originally at MIT (Forrester 1961, Robert 1978, Richardson and Paugh 1981, Meadows, 1982). For systems theorists, the root of substandard performance, organizational failure, and inability to adjust is usually attributed to individuals' bounded rationality (Simon 1979). This bounded rationality is manifested by the limited cognitive skills and capabilities of individuals compared to the complexity of the systems they are responsible for managing. The real-life decision making situations have usually indirect, nonlinear, delayed effects, and are very dynamic in nature. These realities makes rational systematic decision making a very complex function. Misperception of multiple and delayed feedback has led to the failure of many organizations (Sterman, 1988, Hall 1989).

THE PROJECT

The History of System Thinking at AU

AU decided from the start not to depend solely on an external consultant to build the model and then explain its operation to policy makers. The "traditional role" of external consultant as developer and interpreter was believed not to provide AU with the sought organizational learning. AU's president, who was introduced in 1991 to systems dynamics new technologies during his sabbatical in the Boston area, decided that if AU were to adopt a systems thinking approach, internal expertise should be developed in this field. A one week seminar was organized in December, 1991 by Gould-Kreutzer Associate (a system thinking consulting firm based in Boston) which was attended by top AU executives. This seminar helped a great deal in introducing the terminology and technologies of systems thinking to AU. In the summer of 1992, an AU task force was formed and provided the necessary specialized training, which included hands-on training on STELLA® and Microworld programs. A prototype of a comprehensive AU simulation model was then built by the AU task force, in collaboration with Gould-Kreutzer Associates (Mahmoud, 1992). The prototype model was then introduced to AU Governing Council, who played the game version of the model and appreciated its strength as a decision making tool. The process of building the AU microworld model gave AU model builders a chance to develop their skills in scientific method, system thinking, and critical thought. As Senge and Sterman (1990) stressed, "Passive consumption of model results does not transfer systems thinking ability into an organization, nor does it develop the discipline of scientific experimentation necessary to learn effectively from experience."

Two fundamental questions where learning was required were, "Why has the university grown so rapidly?" and "What are the limits to its future growth?" The course in Systems Thinking provided several necessary things to management that did not exist previously: 1) a common language, 2) an appreciation of the university as one large system, and 3) system dynamics learning tools to better understand the behaviours, decisions, and policies that brought about success. After the initial one week course in Systems Thinking senior management recommended the development of a university system model similar to the People Express® management flight simulator. The university simulator could also serve as memory and a record of institutional learning.

System Dynamic Modelling

Decision making in dynamic organizations is highly complex, and managerial choices are far from trivial. The fact that managers have difficulty learning from real-life experiences compounds the problem, especially when the decisions and their consequences are separated in time and space. Operations at AU are a typical example of where long time lags between decisions and their consequences have prevented managers of different parts of the system from drawing appropriate lessons from failures. The attempt of managers to focus on their own subsystems has resulted in their inability to understand the

inter-dependency of different sub-systems. The use of feedback can be effective only if cause and effect are closely related in time and space. The problems inherent in learning from unguided organizational experiences are compounded by ever scarcer time available for learning. In such cases, Management flight simulators (or learning laboratories) can provide Microworlds® in which assumptions, relationships, and outcomes can be tested, thereby shortening the feedback cycle time in situations where delays are inherently long.

STELLA® Model

In this type of modelling university systems are characterized by having several *levels* (stocks) which are influenced by their respective inflows and outflows. Levels are the accumulations within the system. They are the present values of those variables that have resulted from the accumulated difference between inflows and outflows. *Flow rates* define the present, instantaneous flows between the levels in the system. The rates correspond to activities (i.e., registration, course development, course production, course delivery), while levels measure the resulting state to which the system has been brought by the activity (e.g., admissions, registrations, courses being written, produced, delivered). If all the activity in the system is momentarily stopped, rates are not observable, but levels continue to exist. Rates of flow are determined by the levels of the system according to rules defined by the decision function (e.g., rate of registration can be influenced by size and number of tutor blocks allocated).

INSIGHTS INTO THE DYNAMICS OF AU

Growth Dynamics

One of the questions to be answered at the start of the model building process was, "What is the engine of growth for the university?" The answer came rather quickly but needed verification throughout the model development. The engine of growth for the university was its course offerings. Students would come if the desired courses were available for registration. Course demand could be for individual study or for program completion.

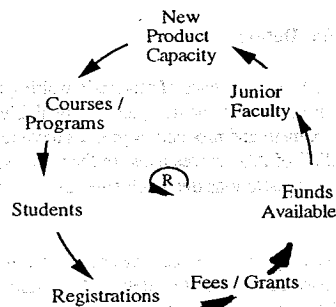
In reviewing course registrations over the past five years it became apparent that although all courses cost relatively the same to develop, not all courses had the same demand once they became available. The university course offerings doubled from approximately 100 courses in 1985 to 200 in 1990. During this time period over 60 percent of course registrations were achieved from less than 10 percent of course offerings. In addition, less than 10 percent of course registrations were achieved from more than 30 percent of course offerings.

To better capture this phenomena into the model courses were classified into: 1) high-registration courses, 2) medium-registration courses, and 3) low-registration courses and reviewed over time to see the dynamic relationship of course availability and course demand. It was very clear that not all courses were market winners, but yet some courses were required by curriculum.

As well, management of course availability and unavailability due to course revision and development schedules required attention to the impact on university registrations. A single high-registration course being unavailable would significantly affect overall university registrations whereas a single low-registration course would have significantly less effect.

The Cost Structure of Course Development

The human resources required for course development are broken down into several categories: 1) faculty or SMEs to author the courses, 2) fulltime or contract editorial staff to finalize the manuscripts, and 3) media design, pre-production and printing staff. The capital resources required for AU's electronic course development and production process are: 1) computers for



Growth Dynamics:
 More Courses = More Students = More Fees & Grants
 = More Faculty = More Capacity

electronic author and editing of manuscripts, 2) computers for electronic composition and design of courses, 3) computers for pre-production and electronic storage of completed course document, and 4) high speed Docutech photocopiers and high volume Heidelberg printing presses for reproduction connected by electronic interfaces. As well, there is a complete set of capital equipment for final binding and finishing of course packages.

Two printing methods are mixed to keep costs under control in the production process. For instance, the high speed Docutech photocopiers are more expensive for large volume courses but are less expensive for small volume courses. The high volume Heidelberg presses are still the cheapest route for high volume courses. Large volume courses are usually stored in inventory while low volume courses are printed from a computer file as needed providing just-in-time inventory to reduce carrying costs.

The traditional model for the university provides for newly hired faculty to develop a course as part of their pre-tenure workload. In most cases new faculty author one or more courses prior to receiving tenure. Tenured faculty usually spend less time on course development and more time on disciplinary research and course management. After a course is developed by a faculty the course delivery for the same course is managed by the same.

An alternative model emerged over the years to permit faculty to hire course authors on contract and these SMEs provided a course product to the university over a specified time frame for a set fee. The use of SMEs grew especially amongst tenured faculty in areas when development schedules required fast-track development.

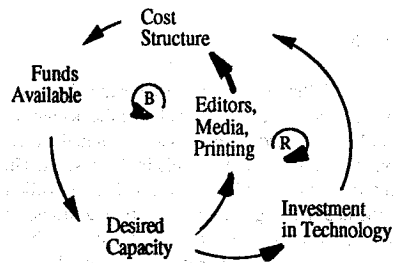
Queues and Delays

Delays, in the form of queues of materials waiting for editing, or students waiting for registration because of tutor assignment or courses not being open and available, quickly became apparent through the model building. Delays in the course development and production process have resulted in considerable inefficiencies in the AU operation. At one point in time, up to 20% of AU courses listed in the university calendar were closed for lack of materials. Besides the considerable loss of course registrations due to closure, this can result in increasingly dissatisfied students, and potential customer defection.

Queues at one stage of the process can result in un-intended delay and negative behaviour at other parts of the system, which in turn increased the total system delays. For example, if course authors and editors notice a long queue at Media (implied by long delays) they tend to slow down their course writing and editing process. Because of the delay in the communication between Faculties and Media, queues start to build up at the faculty level while vanishing at Media level. When the organizational blame for course closure is now aimed at the faculties, authors and editors start to accelerate their work, which results in a massive flow of materials from faculties to Media. This puts the system back at its original condition of long queues at Media, and short one at Faculties. The model developed a simulation enabling those involved at each stage of the process to see and understand the behaviour of the bottlenecks and delays occurring in course development and production process. Also, the model gave insight into potential bottlenecks that were likely to occur in the future if several key decisions were not made about human resources and workload or capital investment in technology.

Course Delivery

Each member of faculty is assigned a number of tutors to handle the expected number of student enrolments and likewise each tutor is assigned a responsibility for preassigned number of registrations (block size) called the tutor block. The current delivery model has fixed and variable costs components that are driven by the number of registrations in their course block. The number of blocks allocated to tutors and the block size for each block contract are the primary determinants of the cost of

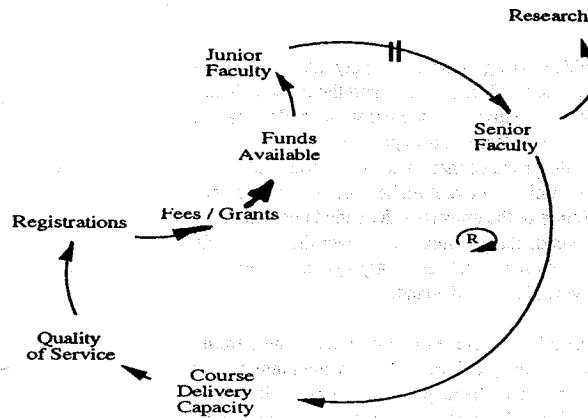


Limit: More Capacity = Higher Cost Structure
= Less Funds Available

Response to Limit:
Invest in Technology = More efficiency = Lower Cost Structure

the course delivery system. For instance any small increase in the block size would provide significant cost efficiencies because of the mix of fixed and variable costs structures inherent in the design.

The capacity of the current course delivery system determined on a course by course basis. Not all courses can be delivered with the same student/tutor ratio. Senior courses and some special course require low ratio design, while some popular high enrolment courses can be delivered using a high ratio design. Overall, there appears to be great potential for cost efficiencies in the current delivery model providing the opportunity for reallocation of resources based upon continuous monitoring and management of block size.

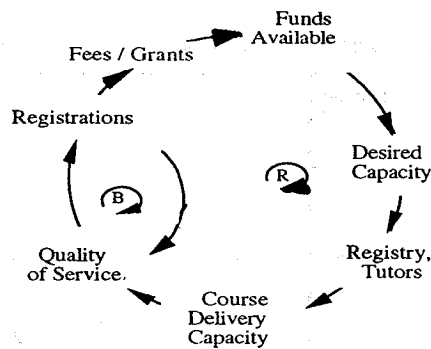


Growth Dynamics:
Over Time; Junior Faculty become Senior Faculty and can spend more time delivering existing courses and improving the quality of service.

Possible Limit:
Senior Faculty spend a proportionately greater share of their time on research

Service Quality

Many strategic and operational decisions made at the university had direct or indirect implications on the quality of services offered to our customers (students). Tutor block size, quality of course materials, course availability, rate of course revisions, ratio of tutors to faculty, and turn around rates for exams and assignments are examples of quality factors. The availability of tutor blocks and the block size ultimately place a constraint upon the ability to serve students if demand is continuous. Optimally, alternate course delivery models need to be developed as some students who are currently waiting for tutor assignment are completing course materials independently and sending in assignments for marking and call for the final exam prior to tutor assignment. A viable option being contemplated is to allow students the freedom to take courses without a tutor, once they have developed the ability to adapt to the home-study model. Most students capable of doing this are senior students who understand the current delivery model. Of course not all courses can be completed without a tutor, but the need for options in course delivery is apparent and desired from the students perspective.



Limit: More Registrations = Less Quality

Response to Limit:
Invest in People / Capacity to expand Service and increase Quality.

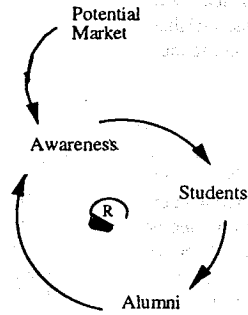
The market for potential new students

A demographic model of the provincial post-secondary education system was created to determine, based upon birth rate, the flow of students into the post-secondary system, the participation rate and demand for a part-time university education in the Province of Alberta. The demographic trends simulated using the model revealed potential markets for various ages groups

that had low participation rates at present as well as those age group markets that were nearing saturation with high participation rates.

The demographic model graphically display the participation rate for the population of the province and the market share being served by each university in the post-secondary system. Competitive analysis clearly shows potential unserved markets within the province that could be targeted and also the participation limits of market niche. As well, it became clear that the future of the university depended upon finding new markets outside the province since, over time, the built capacity of the provincial post-secondary system would exceed the provincial market demand.

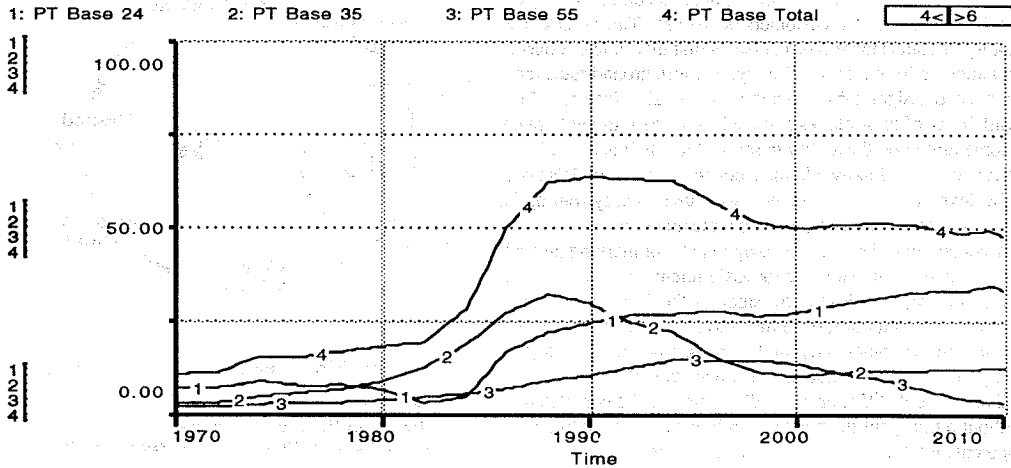
Historically, the primary source of new students came from the major centres of the province and a growing number were already enrolled at other Alberta post-secondary institutions. Awareness of AU and its course offerings was assumed to be by word-of-mouth, since no history of target marketing existed or was available. Therefore, the assumption used was that the word-of-mouth message would affect the potential for recruitment of new students.



Growth Dynamics:
More Students = More Alumni (word of mouth effect) = More Awareness

Limit: What is the size of the potential market?

Target marketing has been successful for customized programs for business and employees of those businesses who are registered in courses of the programs. However, tracking of marketing success has not been done. It is necessary to track marketing efforts to know how much effort, time and finances are need to achieve a certain level of recruitment.



Demographic trends show that the participation rate of students age 25-44 peaked prior to 1990. Whereas, the participation rates of those in the 18-24 age and 45-65+ age group are steadily rising well toward the year 2000.

SCENARIO TESTING

The AU Microworld system has been used to test different scenarios and strategic options. The long-term implications of different scenarios are almost impossible to predict without such a dynamic system and model. Each scenario includes setting of the policy choice and decision variables, such as: rate of new course proposals, rates of faculty hiring and exit, SME budget, percent of faculty time spent in course development, rates of editor hiring and exit, percent of editor time spent in course editing, part-time editor budget, editor time per course, average pages per course, block size, rate of graphical designer hiring and exit, rate of investment in printing capital, printing capital productivity (technology), and average shelf life. AU Microworld scenarios can be simulated for 10 years, 1990 - 2000.

Repeated runs of the simulations have proved that quick fixes to one part of the system do not necessarily help the overall performance. For example, eliminating queues at one subsystem of the course development and production process means simply shifting the queue to the next subsystem down the stream. Over-spending at one subsystem, as a reaction to a long queue, can also be justified. The best strategy is the one which balances the flow rate throughout the system with the proper consideration to the cost factor. The systems thinking approach adopted for modelling the university system has provided AU managers with a framework for understanding and discussing the relationships between model structure, scenario behaviour, and the real system. It has been found that the process of constructing a simulation model is as valuable for problem solving as the final model itself.

LOOKING FORWARD

The AU Microworld (a management flight simulator) is now being used as a planning tool for re-engineering at the University. Future growth of the university depends on making the correct mix of strategic decisions and policies that will meet the needs of students. The university has to be flexible and responsive to the trends and shifts in the market with the differentiated services as demanded by students.

As evidence of the significant contribution of the institutional learning from the development of the management flight simulator it will be used as a decision support system for enrolment management and for analysis of performance indicators on a continuing basis. All management information systems of the university will be streamlined to integrate with the AU Microworld. The Microworld will provide university managers with scenario planning tools for learning. For instance, it will provide support to course management, faculty workload analysis, and accountability will be developed through the integration of statistical and financial management of course offerings. The model will simulate impacts of long term strategies and the effect of policy decisions, providing feedback prior to the decisions being made.

In conclusion, the university has certainly benefited by the development of a Microworld. The benefits are efficient and centralized planning, decentralized decision making and resource allocation to faculty, and clear communication of results in a timely manner.

REFERENCES

- Argyris, C. and Schon, D., "Organizational Learning: A Theory of Action Perspective, Reading, MA: Addison-Wesley, 1978.
- Bakken B., J. Gould, and D. Kim, "Experimentation in Learning Organizations: A Management Flight Simulator Approach", Working paper 3274-91-BPS, Sloan School of Management, MIT, Cambridge, MA, 1991.
- Forrester, J. W., Industrial Dynamic, Cambridge, MIT Press, 1961.
- Graham, A., P. Senge, J. Sterman, and J. Morecroft, "Computer-Based Case Studies in Management Education and Research. In Milling, P. and E. Zahn (eds), Computer Based Management of Complex Systems. Berlin: Springer Verlag, pp. 317-326.
- Hogarth, R., Judgement and Choice. 2nd Edition. Chichester: John Wiley., 1987.
- Mahmoud, M. M., "System Dynamics Simulation for the Management of an Open University," The Joint ORSA/TIMS National Meeting, San Francisco, LA., November 1-4, 1992.
- Meadows, D. H., Whole Earth Models and Systems, Co-Evolution Quarterly, Summer 1982.
- Papert, S., Mindstorm, New York: Basic Books, 1981.
- Peterson, S. "designing Learning Environment", Proceedings of the 1990 International System Dynamics Conference, Chestnut Hill, Mass., 1990.
- Richardson, G. P., "System Dynamic Thinking: A Critical Set of Critical Thinking Skills for the 90's and Beyond", Proceedings of the 1990 International System Dynamics Conference, Chestnut Hill, Mass., 1990.
- Richardson, G. P. and A. Pugh, Introduction to System Dynamics Modelling With DYNAMO. Cambridge: The MIT Press, 1981.
- Robert, E. B., Managerial Applications of Systems Dynamics. Cambridge.: MIT Press, 1978.
- Senge, P. M., The Fifth Discipline, New York: Doubleday, 1990.
- Senge, P. M., and J. D. Sterman, "Systems Thinking and Organizational Learning: Acting Locally and Thinking Globally in the Organization of the Future," Proceedings of the 1990 International System Dynamics Conference, Chestnut Hill, Mass., 1990.
- Simon, H. A., Rational Decision Making in Business Organizations, American Economic Review, 69, 1979, pp. 493-513.
- Stata, R., "Organizational Learning -- The Key to Management Innovation," Sloan Management Review, 30, 3, Spring 1989, pp. 63-74.
- Sterman, People Express Management Flight Simulator. Software and Briefing Book. Available from Author, Sloan School of Management, MIT, Cambridge MA 02139.